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ON THE VERTICAL DISTRIBUTION OF WATER VAPOR IN THE MARTIAN TROPICS. Robert M. Haberle, NASA/Ames Research Center, Moffett Field, CA 94035.

Although measurements of the column abundance of atmospheric water vapor on Mars have been made (1,2), measurements of its vertical distribution have not. How water is distributed in the vertical is fundamental to atmosphere-surface exchange processes, and especially to transport within the atmosphere. Several lines of evidence suggest that in the lowest several scale heights of the atmosphere, water vapor is nearly-uniformly distributed (3). However, most of these arguments are suggestive rather than conclusive since they only demonstrate that the altitude to saturation is very high if the observed amount of water vapor is distributed uniformly. The purpose of this paper is to present a simple yet compelling argument, independent of the saturation constraint, which suggests that in tropical regions, water vapor on Mars should be very nearly uniformly mixed on an annual and zonally averaged basis.

To begin the discussion consider the situation for Earth. On Earth, the average annual precipitation at any given latitude does not necessarily balance the average annual evaporation. Near the equator for example, precipitation exceeds evaporation (4). From the point of view of the atmosphere, therefore, this region is a moisture sink, and water vapor must be transported in to maintain the long-term balance. At these latitudes the transport is accomplished mainly by the thermally driven mean meridional circulation (Hadley Cell). To accomplish this transport, however, the water vapor mixing ratio (specific humidity) must decrease with height in the mean. This is, of course, the situation for Earth: the concentration of water vapor is a strong function of height.

For Mars, however, the situation is different since it has no oceans to redistribute water meridionally. As a consequence, any difference between the average annual precipitation and evaporation at a given latitude must result in a change in the size of surface ice deposits. The only regions on the planet where ice can exist all year long are the polar regions, but it is not known if these reservoirs are changing or not. On the one hand, Davies (1980) has suggested that there is no net annual change in the size of polar reservoirs (5), in

which case precipitation and evaporation are balanced at all latitudes and there is no net meridional transport. This implies, in turn, that water vapor must be uniformly mixed in the tropics where transport by the mean meridional circulation dominates. On the other hand, Jakosky (1983) has argued that the existence of a north-south gradient in column water vapor implies a net southward transport of water from the north cap to the south cap (6). An upper limit for this transport is $5x10^{11}$ Kg per Mars year. Based on model estimates of the Martian Hadley cell mass flux (7), it can be shown that this transport can be achieved with a tropical mixing ratio that decreases by less than 10% of its near surface value.

There is yet another possibility. Water could be redistributed globally in subpermafrost aquifers (8). According to Clifford (1981), water thermally diffuses to the surface from this aquifer in equatorial regions, is transported to the poles where it precipitates, and then passes back into the groundwater system when melting occurs at the base of the polar caps. He estimates that as much a $1km^3$ of water may be introduced into the crust each Martian year in this manner. This amount, however, is only a factor of two larger than Jakosky's north-south transport and we still expect, therefore, water vapor to be nearly uniformly mixed in the tropics.

It should be emphasized that this conclusion is for annual mean conditions. Given the expected large seasonal variations in the structure and intensity of the Martian circulation, departures from uniform mixing are certainly possible. However in the annual mean, it appears that water must be nearly uniformly distributed in height on Mars, at least in the tropics. If future observations by the Mars Observer spacecraft find otherwise, then significant sources and sinks for water must exist at the surface.

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